WoLiM 1.5 User guide

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Summary

This document is the User's Guide of the WOLIM 1.5 model. This model version is implemented in Vensim, and includes an excel template that operates as an interface that allows for those users not familiar with Vensim to design and run their own scenarios. The model can be run with the freeware software "Vensim Model Reader", while more advanced users can also perform changes in the structure of the model (Vensim DSS proprietary software required for the latter). The model is available for any user under the condition of recognizing its authorship citing the following references: (Capellán-Pérez et al., 2014a, 2017).

Table of contents

1. Introduction 3
2. Download Vensim software 3
3. Use of Vensim software 3
4. Download model and associated files: 3
5. Open the model and upload of scenarios 4
6. Run of scenarios 6
   6.1. By-default scenarios 6
   6.2. Customized scenarios 8
   6.3. Modify the structure of the model 10
7. Visualization of results 10

1. Introduction

This User's Guide explains the methodology to run the WOLIM 1.5 model. This version is similar to the WOLIM 1.0 documented in (Capellán-Pérez et al., 2014a) & (Capellán-Pérez et al., 2014b), but however presents some improvements and changes (see the updated Technical Report (Capellán-Pérez et al., 2017)).

2. Download Vensim software

Follow instructions and download here: http://vensim.com/vensim-software/.

3. Use of Vensim software

For begginer users using the freeware Vensim Reader software, when opening the software a short tutorial will appear. It is recommended to follow it to learn the basics (see equation definig a variable, represent a result in a graph, etc.).

For advanced users using the Vensim DSS version or superior, official tutorials and Help page in the official web are recommended.

4. Download model and associated files:

The model is available for download in the following link:

http://www.eis.uva.es/energiasostenible/?page_id=2056

When downloading and uncompressing the file ***WoLiM1_5+TR-to-share.zip***, the following files can be found:

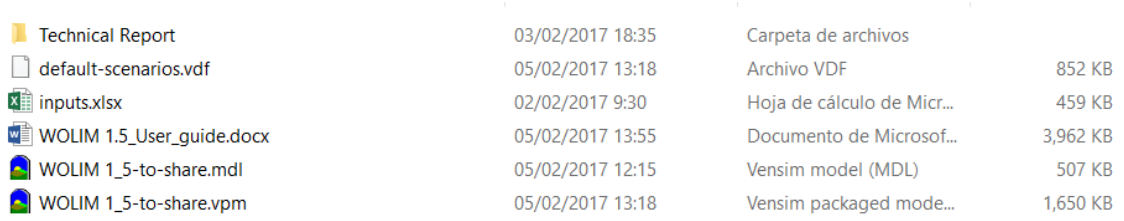


Figure 1

The folder **Technical Report** includes the Technical report and the equations of the model.

WOLIM 1.5_User_guide.docx is the User guide to run the model (this document).

WOLIM_1.5-to-share.mdl is the full model programmed in Vensim, which allows to open, explore, simulate and modify the structure of the model. To open and work with this file, the proprietary software Vensim DSS version or superior is required (http://www.vensim.com).

WOLIM_1.5-to-share.vmf allows to open, explore and simulate the model with freeware "Vensim Model Reader" is required (http://vensim.com/vensim-model-

reader/). This file is associated to **default-scenarios.vdf**, which already includes the results of the default-scenarios (see section 6.1).

The file **inputs.xlsx** stores the input data required for running the by-default scenarios and creating new ones. This file contains a tab “README” and “Info input variables” which document the way the variables are organized and defined in the data sheet. IMPORTANT: Do not modify the names of the excel file neither those of the tabs since the paths with Vensim are not dynamically set.

*Additional software requirements: A version of Microsoft Excel allowing to work with tabs.

5. Open the model and upload of scenarios

Open the model (file **WOLIM_1.5-to-share.vmf** or **WOLIM_1.5-to-share.mdl)**. Vensim will automatically upload the scenarios BAU, 1, 2, 3 & 4 from **inputs.xlsx** (which correspond to the scenarios published in Capellán-Pérez et al., (2014a)). The first view of WOLIM should then appear relative to the socioeconomic variables “GDP and Population”:

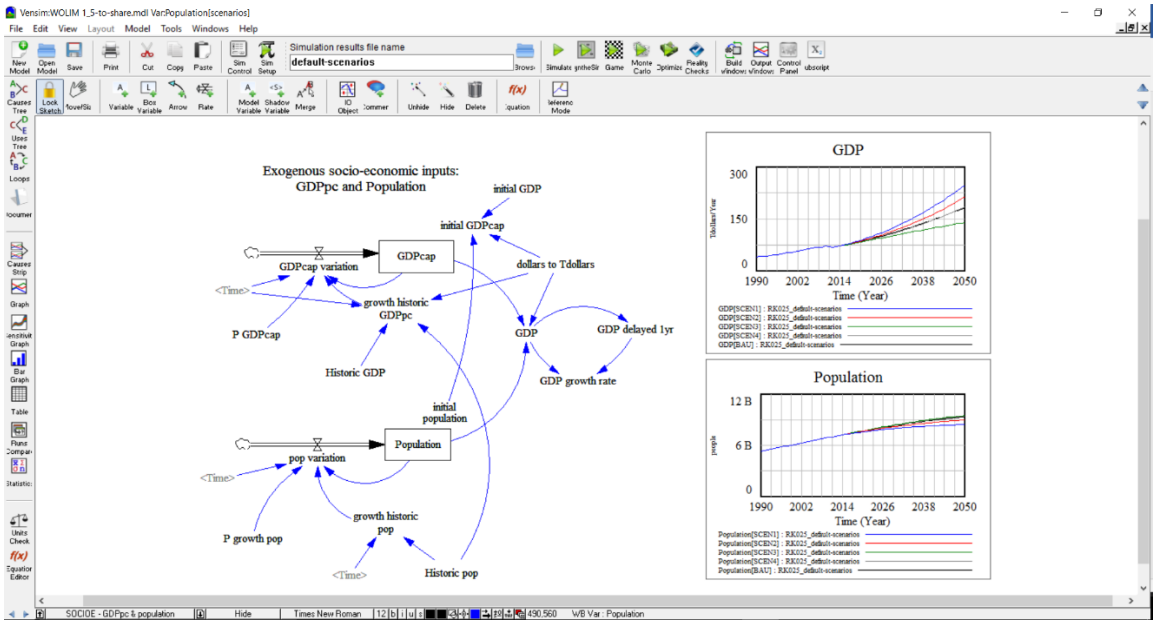


Figure 2

The model is composed by about 60 views: most of them constitute the structure of the model (~40), while the remaining starting by “PC” (Panel Control) visualize the main results:

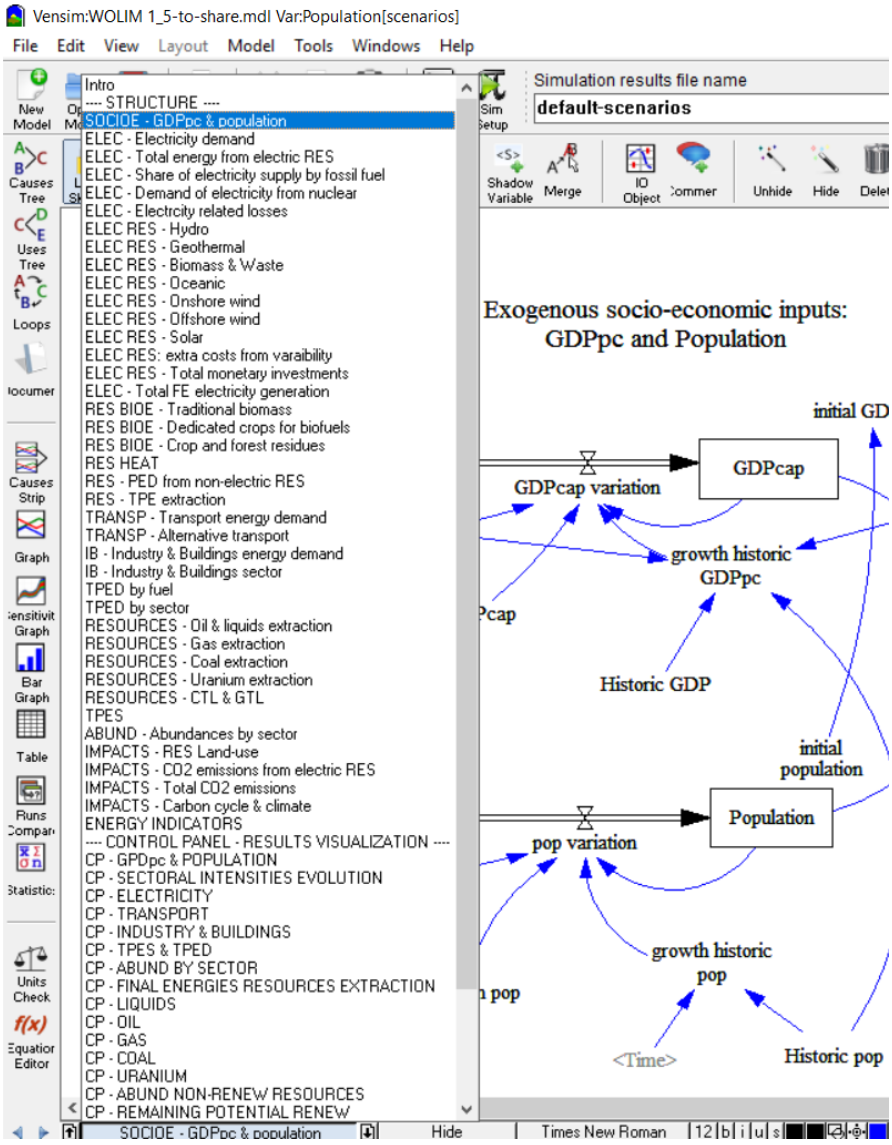


Figure 3

To see the next view showing the modelling of electricity generation from solar use the "Page up" ("Page up" to return), or click in the arrow in the bottom left part:

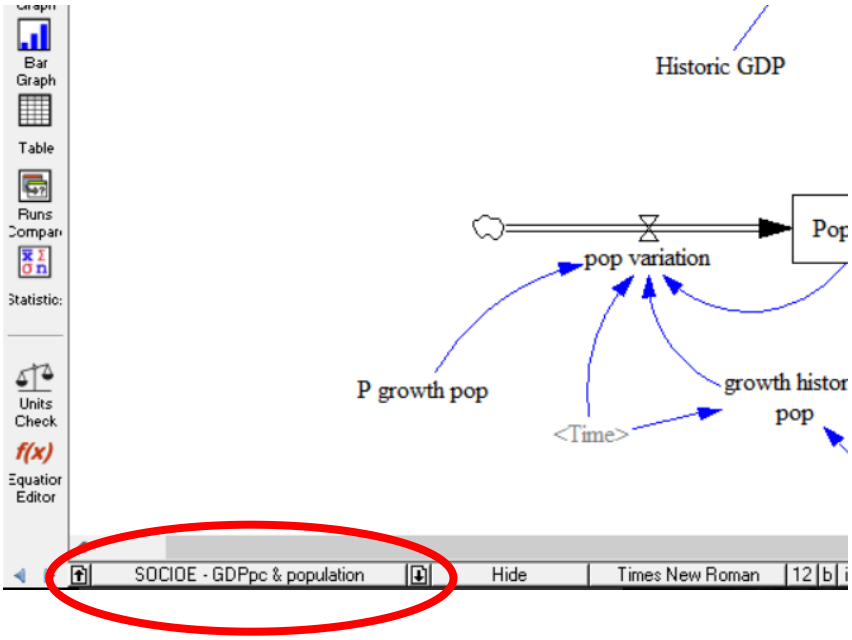


Figure 4

6. Run of scenarios

Note: RK4 integration type is recommended.

This model version is programmed vectorially, so 6 scenarios (User define, BAU, 1, 2, 3 & 4) are always run in parallel. The user can select which one to represent.

6.1. By-default scenarios

To run the by-default scenarios (BAU, 1, 2, 3 & 4) again, just press the button *Simulate*, located in the upper part of the screen (please note that with the Vensim Reader the name of the simulation should be changed to re-run the by-default scenarios since the software does not allow to overwrite them):

Figure 5

The input data for the scenarios are taken from the file **inputs.xlsx**. For each scenario there is an independent sheet. In each scenario, different assumptions are made for each input. In each scenario, the input data correspond to the variables from the Table 14 from the Technical Report (Capellán-Pérez et al., 2017) (see below an extract; see also Table 4 from Capellán-Pérez et al., (2014a)):

	SCENARIO - INPUT	BAU Projection of current trends	Scenario 1 Economic optimism with some market reforming	Scenario 2 Global Sustainable Development	Scenario 3 Regional competition	Scenario 4 Regional sustainable development
Socioeconomic (% 2015-2050)	GDPcap	Hist + 1.9% (1960-12)	+ 3%	+ 2.4%	+ 1.1%	+ 1.9%
	Population	UN Medium-Variant +0.75%	+0.5%	+0.65%	+0.81%	+ 0.8%
Sectoral efficiency improvements	a_{Transp}	Past trends (-0.67%)	Rapid (-0.9 %)	Rapid (-0.9 %)	Deglobalization (-1.5%)	Deglobalization (-1.5%)
	a_{elec}	Past trends (0%)				
	a_{BI}	Past trends (-0.5%)	Past trends (-0.5%)	Past trends (-0.5%)	Past trends (-0.5%)	Past trends (-0.5%)
	I_{min}[a]	35 %	35 %	25 %	35 %	25 %
Resource availability	Non-renewables	Best Guess	Best guess (coal, conv. oil) High case (gas, unconv. oil)	Best Guess	Best Guess	Best Guess
	CTL, GTL[b]	Crash program (+15 %)	Crash program (+20 %)	Past trends	Crash program (+15 %)	Past trends
Electric RES	Solar FV&CSP	Medium (+15%)	Past trends (+19%)	Very rapid (+25%)	Medium (+15 %)	Very rapid (+25%)
	Wind	Medium (+20%)	Past trends (+26%)	Very rapid (+30%)	Medium (+15%)	Very rapid (+30%)

Figure 6

Some warnings might arise due to the use of the RK integration method, ignore them (to avoid this to happen select: *Tools->Options->Settings->Suppress warning*):

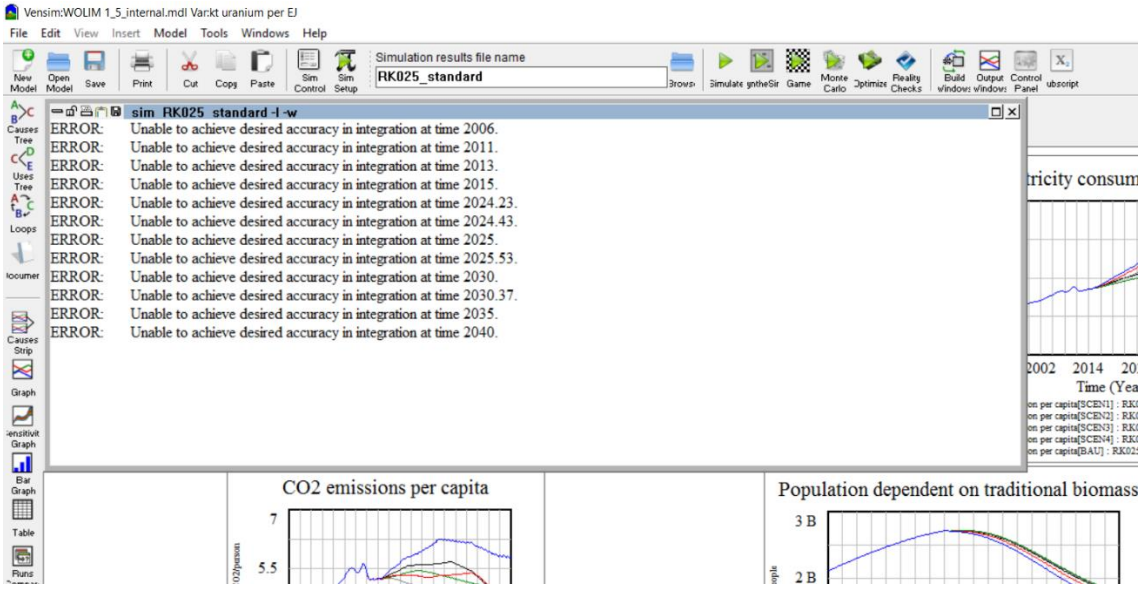


Figure 7

For example, for the variable “P solar”, which represents the annual growth in energy output demand from solar electric technologies, data from the C38 cell (circled in black bold) from the scenario BAU (in red, sheet “BAU”) are required. Vensim reads the excel file **inputs.xlsx** as follows:

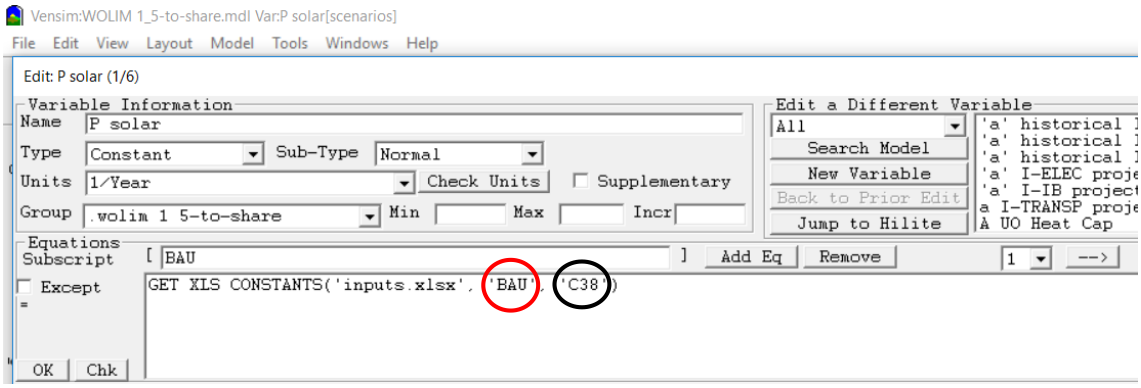
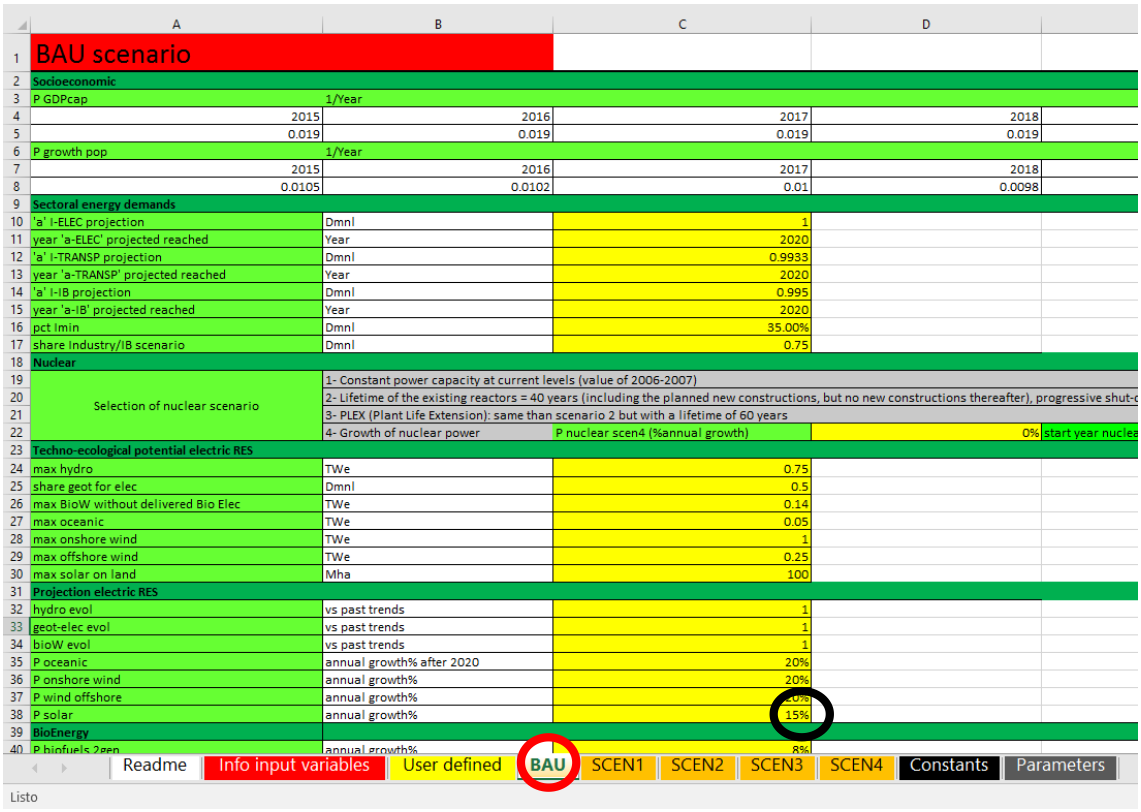


Figure 8

Tab “BAU” and cell “C38” in excel file:



	A	B	C	D
1	BAU scenario			
2	Socioeconomic			
3	P GDPcap	1/Year		
4	2015	2016	2017	2018
5	0.019	0.019	0.019	0.019
6	P growth pop	1/Year		
7	2015	2016	2017	2018
8	0.0105	0.0102	0.01	0.0098
9	Sectoral energy demands			
10	'a' I-ELEC projection	Dmnl	1	
11	year 'a-ELEC' projected reached	Year	2020	
12	'a' I-TRANSP projection	Dmnl	0.9933	
13	year 'a-TRANSP' projected reached	Year	2020	
14	'a' I-IB projection	Dmnl	0.995	
15	year 'a-IB' projected reached	Year	2020	
16	pct Imin	Dmnl	35.00%	
17	share Industry/IB scenario	Dmnl	0.75	
18	Nuclear			
19	Selection of nuclear scenario	1- Constant power capacity at current levels (value of 2006-2007)		
20		2- Lifetime of the existing reactors = 40 years (including the planned new constructions, but no new constructions thereafter), progressive shut-d		
21		3- PLEX (Plant Life Extension): same than scenario 2 but with a lifetime of 60 years		
22		4- Growth of nuclear power	P nuclear scen4 (%annual growth)	0% start year nuclea
23	Techno-ecological potential electric RES			
24	max hydro	TWe	0.75	
25	share geot for elec	Dmnl	0.5	
26	max BioW without delivered Bio Elec	TWe	0.14	
27	max oceanic	TWe	0.05	
28	max onshore wind	TWe	1	
29	max offshore wind	TWe	0.25	
30	max solar on land	Mha	100	
31	Projection electric RES			
32	hydro evol	vs past trends	1	
33	geot-elec evol	vs past trends	1	
34	bioW evol	vs past trends	1	
35	P oceanic	annual growth% after 2020	20%	
36	P onshore wind	annual growth%	20%	
37	P wind offshore	annual growth%	20%	
38	P solar	annual growth%	15%	
39	BioEnergy			
40	P biofuels 2gen	annual growth%	8%	

Readme | Info input variables | User defined | BAU | SCEN1 | SCEN2 | SCEN3 | SCEN4 | Constants | Parameters

Listo

Figure 9

The output of the simulations is stored in a .vdf file: **default-scenarios.vdf**.

6.2. Customized scenarios

It is possible to build a customized scenario by modifying the inputs in the sheet “User define” in the file **inputs.xlsx** with both the “Vensim Model Reader” and the “Vensim DSS” versions (see Tab “User defined” in previous figure).

There are 3 different ways of modyfing inputs to the model:

1. Introducing a numerical value (shown in previous section)
2. Introducing a time series (see variable “P GDPpc” in lines 4 and 5 in Figure 9)
3. While for others a choice has to be done between different options, e.g. “Selection of conv oil curve” selecting the option 1,2, 3 or 4 (in the example in Figure 10, the option 2 is selected –see black bold circle-):

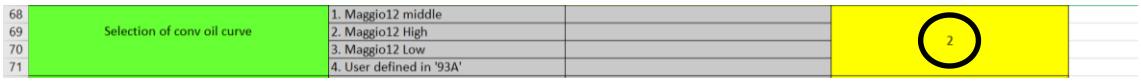


Figure 10

The rest of variables used by the model which remain constant through the by-default scenarios are located in the sheets “Constants" and “Parameters”:

- *Constants*: units conversion, historical values, etc.

- *Parameters*: variables that are considered as constants in the by-default simulations but that may be different following other assumptions.

For comparing the results of our User Defined scenario, it is necessary to change the default options in Vensim. For this, click in the “Subscript” button:

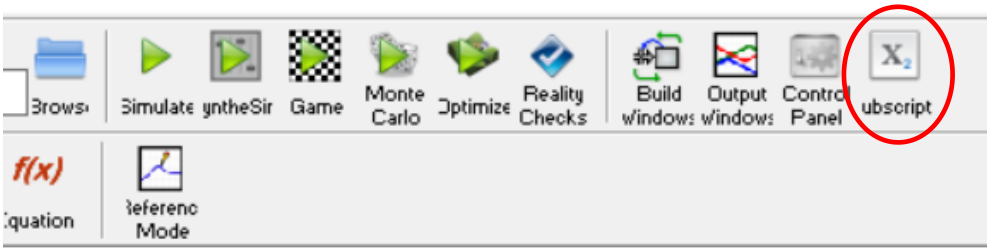


Figure 11

And in the tab “scenario” we select the scenarios that we want to run (i.e. it is possible to run the “User define” scenario and compare with the by-default scenarios):

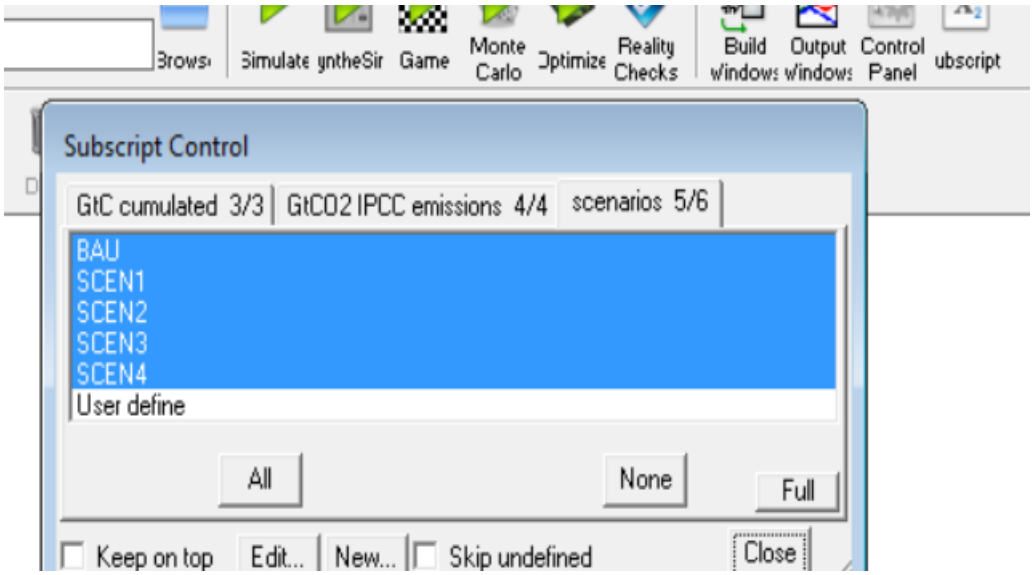


Figure 12

If different simulations are made, the user can remove and or select the ones to be displayed clicking in the option “Control panel”. In the example below, two scenarios have been run, but only the “default-scenarios2” will be displayed:

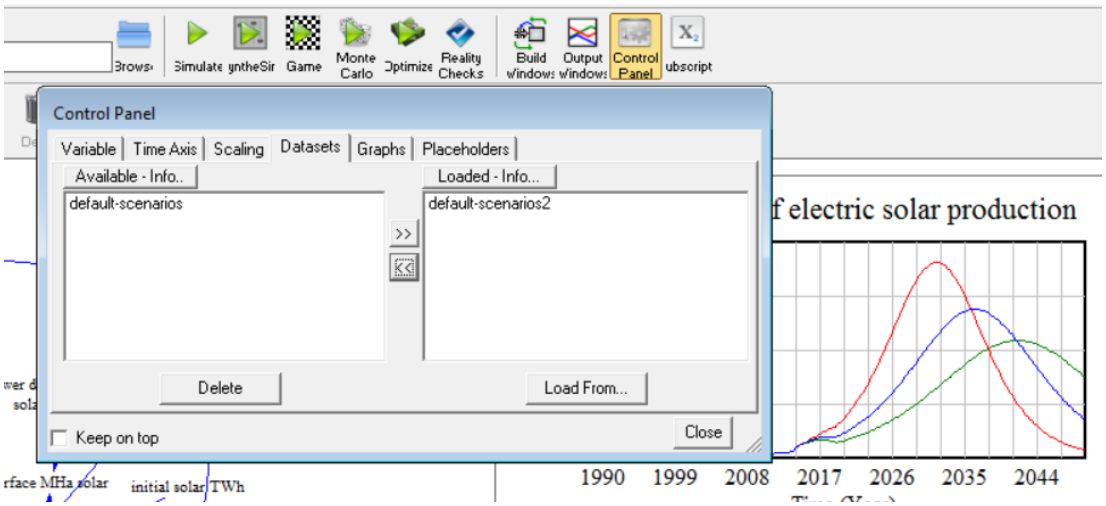


Figure 13

6.3. Modify the structure of the model

Users are welcomed to modify the structure of the model in Vensim as well as the input data file "**inputs.xlsx**". For this, the proprietary software Vensim DSS version or superior is required (http://www.vensim.com); “Vensim Model Reader” will not allow to make changes in the structure. For preventing the model from crashing, users just have to make the modifications in both files (excel and Vensim) consistently.

7. Visualization of results

There are two options to visualize the outputs of the model:

1. Go to the “CP-…” views for the automatized Figures in Vensim.

2. Use the Vensim tools to visualize the trajectories of any variable (following the 3 steps described in Figure 14). Outputs of any variable can be exported using Vensim usual tools.

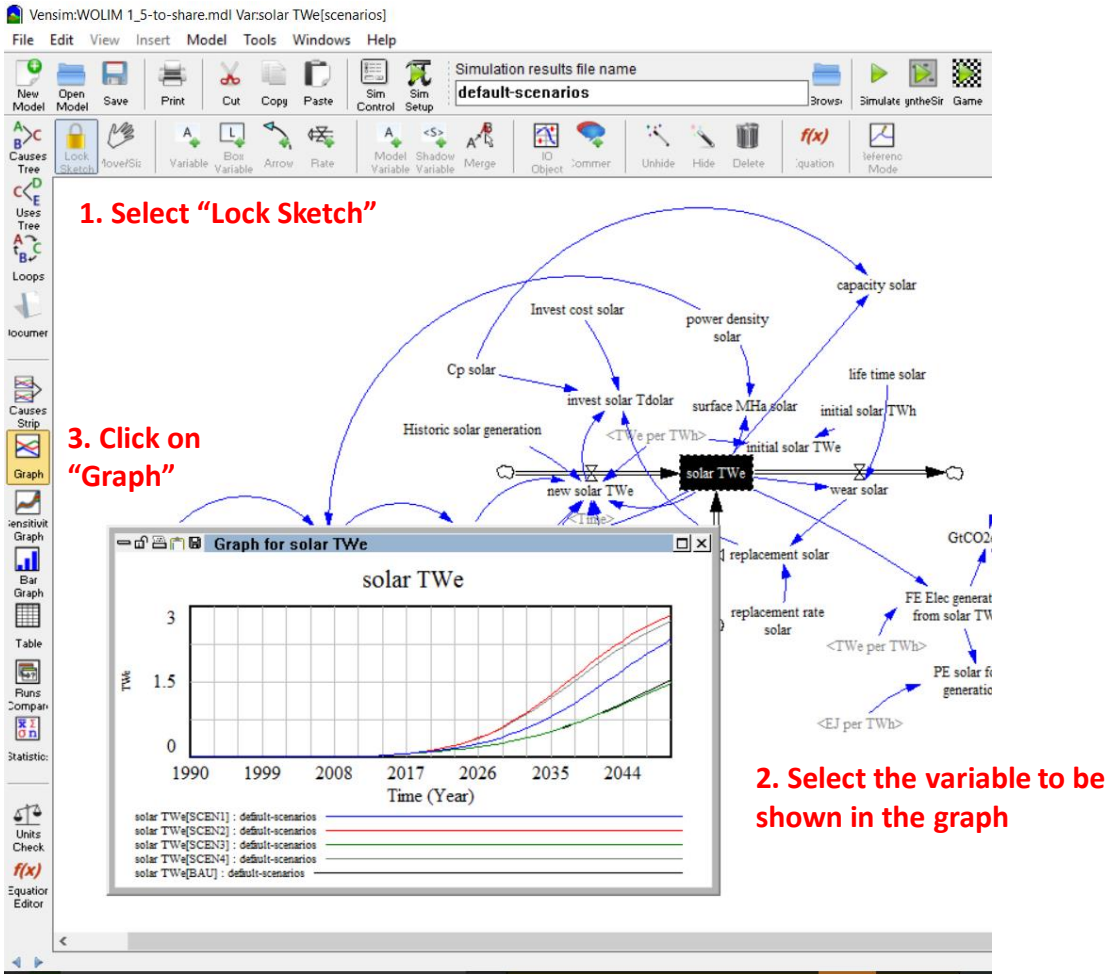


Figure 14

References

Capellán-Pérez, I., de Castro, C., Mediavilla, M., Miguel, L.J., de Blas Sanz, I., Carpintero, Ó., Frechoso, F., Nieto, J., 2017. World Limits Model (WoLiM) 1.5- Model Documentation. Technical Report. Energy, Economy and System Dynamics Group of the University of Valladolid, Spain.

Capellán-Pérez, I., Mediavilla, M., de Castro, C., Carpintero, Ó., Miguel, L.J., 2014a. Fossil fuel depletion and socio-economic scenarios: An integrated approach. Energy 77, 641–666. doi:10.1016/j.energy.2014.09.063

Capellán-Pérez, I., Mediavilla, M., de Castro, C., Miguel, L.J., 2014b. World Limits Model (WoLiM) 1.0 - Model Documentation. Technical Report. Energy, Economy and System Dynamics Group of the University of Valladolid, Spain.